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PARADOXES OF COSMIC FLIGHTS

by

A. Szternfeld

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PARADOXES OF COSMIC FLIGHTS

by Prof. Dr. Ary Szternfeld

In the course of the 13 to 19 years of the realization of cosmic flights there have become familiar many paradoxical phenomena, inconsistent with the experiences of everyday life which are connected with our ideas of the appearance of a force of gravity of determinate magnitude. The motion of artificial heavenly bodies beyond the atmosphere of the earth is subject, however, to the laws of mechanics of the heavens. That peculiar, albeit logically based relationships prevail here, one can convince oneself from the following several instances (examples)

I came across these paradoxical phenomena of which I am writing here during the working out of problems of cosmic navigation. About the fact that there is concerned here, in the face of apparent contradictoriness, logically based phenomena, one can convince himself after investigation of the problems by way of computations.

The PERIGEE PARADOX

The point of departure is constituted by an artificial satellite of the earth, which without crew or people aboard, moves along an elliptic orbit. From it there is about to follow the

takeoff of a rocket. This rocket is about to abandon completely the sphere of gravitational predominance of the earth, in order, for instance, to fulfill assignments for research in cosmic space. Then it is necessary to give the rocket a flight speed. It is obviously possible to accomplish this from a moving satellite, which already has a large circling speed, with the use of less energy than in tha case of a takeoff from the surface of the Earth. During such a takeoff from the earth the rocket motor ought to accomplish a definite acceleration from zero speed to the speed of flight. During takeoff from an earth-circling satellite to the rocket one needs to confer only an increase of speed equal to the difference between the speed of flight and the speed (velocity) already posessed. It is neccessary to determine, however, at what height above the Earth and thus at what point of the elliptic orbit of the artificial satellite is it most advantageous from the energy point of view to set the rocket in motion: at the point closest to the Earth, the perigee, or at the most distant from it,--the apogee?

Since, in agreement with Newton's law of universal gravitation, the force of the Earth's gravity diminishes as the square of the distance, at the apogee there acts on the circling body ((and the rocket) less gravity than at the perigee. This means that at the apogee of the circling orbit the speed of flight is less than at the perigee. When a person is already located in the attic of a building he must exert less effort to extricate himself onto the peak of the roof than if he had climbed from the level of the cellar. Thus indeed one could judge that it will be more advantageous to put the rocket motor into motion at the apogee of the orbit and not at the least distance

from the earth. This seems also obvious as well as logical, but such an understanding is unfortunately false! For one needs here to take into consideration also the fact that the speed of motion of the artificial satellite of the earth along its elliptic orbit changes in a continuous way in accordance with Kepler's second law: this speed is least at the apogee--and greatest at the perigee, and this is a result of the force of gravitation that changes with distance from the center of the earth (on the section of the orbit between the apogee and the perigee the circling body approaches the circled central body and then has a component of motion in the direction of fall, is subject to an acceleration, and on the section between the perigee and the apogee makes itself more distant--raises and therefore eases its motion)

Although at the perigee obviously also, the speed of flight is greater, it appears that the difference of the speeds (velocities) between the circling speed and the speed of flight at the perigee is less than at the apogee. The rocket motor set in motion at the perigee, then, consumes less propulsive materials in order to attain the speed of flight, than after being set in motion at the apogee--the point of least speed of circling and flight. This is not in any way obvious and thus constitutes a paradox.

In order to prove this, one needs to compute the corresponding relations for examples. Let us assume, then, that the satellite, from which the takeoff occurs, circles the Earth along an elliptic path whose perigee is located at a distance of 1/20 of the radius of the planet, ie 319 km from its surface $((h_p)$, while the apogee is distant from it (surface) by two such radii

ie 12756 km/h_a. This is a demonstrative example about the orbit parameters encountered in actual cases. Precisely thus the American artificial satellite of the Earth "ATS 2" ((1967-31A) sent out on April 6th, 1967, had a perigee of 178 km, and an apogee of 11124 km, whereas the "explorer 15" which took off on Oct 27, 1962, posessed a perigee of 313 km and an apogee of 17640 km.

One needs now to compute how great, in actuality, is the speed at the apogee on the orbit selected as an example. One needs here to take into consideration the so-called "zero circling velocity" v_{so} ie the speed of circling which a precise body would have above the equator on a circular orbit ((which could not be realized in actuality, among other things due to the resistance of the air). This speed is v_{sc} = 7.912 m/s.

The radius of the equator of the Earth is equal to r_o = 6378 km. Consequently the distance of the perigee of the contemplated orbit from the center of the Earth will amount to:

$$r_p = r_o + h_p = 6378 + 319 = 6697 \text{ km},$$

and the distance of the apogee:

$$r_a = r_o + h_a = 6378 + 12756 = 19134 \text{ km}.$$

Hence one can determine the size of the large semi-axis a of the elliptic orbit:

$$a = (r_p + r_a):2 = (6697 + 19134):2 = 12917.5 \text{ km}$$

as well as of the small semi-axis b:

$$b = \sqrt{r_p \cdot r_a} = \sqrt{6697 \cdot 19134} = 11320 \text{ km}$$

The circling speed of the circular orbit decreases with the distance from the center of the Earth. At the apogee it amounts to:

$$v_{sp} = v_{so}\sqrt{r_o : r_a} = 7912\sqrt{6378 : 19134} = 4568 \text{ m/s}$$

The actual circling speed on the elliptic orbit is, at the apogee, however, less than the speed v_{sp}, and this is due to the eccentricity of the orbit, the measure of which is the difference of the distances, apogee and perigee, from the center of the Earth.:

$$v_{sa} = {}_{sa}\sqrt{\frac{2r_p}{r_p + r_a}} = 4568\sqrt{\frac{2 \cdot 6697}{6697 + 19134}} = 3289 \text{ m/s}$$

However for the purpose of a complete extricating of one's self to beyond the region of the predominance of the gravitational field of the Earth it is necessary that the object attain a speed of flight v_p. This so-called "second cosmic speed" is always $\sqrt{2}$ times greater than the circular speed on a satellite orbit of the Earth at the same distance from its (earth's) surface, or the so-called "first cosmic speed". Thus the speed of flight on the circling orbit assumed by us will amount to:

$$v_{ua} = v_{sa}\sqrt{2} = 4568\sqrt{2} = 6460 \text{ m/s}$$

At takeoff from the apogee of the circling orbit the rocket engine must add to the object a speed equal to the difference of speeds between the speed of flight from this point and the circling speed along the satellite orbit, and thus confer on this object the additional speed:

$$\Delta v_a = v_{ua} - v_{oa} = 6460 - 3289 = 3171 \text{ m/s}$$

We are pursuading ourselves now as to what additional speed the object must attain during an analogous takeoff from the perigee of a circling (not nec circular) orbit. We are computing this with another method. The circling speed of the satellite at the perigee of the elliptic orbit is greater than the circular speed at the given distance from the center of the earth. In accordance with Kepler's 2nd law, the speed of the satellite at the perigee will amount to:

$$v_p = v_{oa}\frac{r_a}{r_p} = 3289 \cdot \frac{19134}{6697} = 9397 \text{ km/s}$$

The speed of flight on the surface of the earth which amounts to 11189 m/s, at the perigee of the orbit will be equal to:

$$v_{up} = v_{uo}\sqrt{\frac{r_o}{r_p}} = 11189\sqrt{\frac{6378}{6697}} = 10919 \text{ m/s}$$

During takeoff from the perigee the additional speed which the object must attain in this case, will amount then to only:

$$\Delta v_p = 10919 - 9397 = 1522 \text{ m/s}$$

Thus, during takeoff from the perigee with an additional speed of 1522 m/s there is attained the same as during takeoff from the apogee with an additional speed that amounts to, however, 3171 m/s. In the case of takeoff from the perigee there is attained then a significant conservation (saving) of fuel, although the earth is located closer and its gravity operates more powerfully than at the apogee. Both of these mentionned factors are, however, compensated with surplus by the significantly greater momentum which the object has at the perigee.

THE PARADOX OF THE APOGEE

Similarly paradoxical relations arise when it is desired that the cosmic object which is circling the earth, should land on its (earth's) surface. As is well known, one ~~puts into~~ starts motion in this case the rocket engines in the direction opposite to the direction of motion around the satellite orbit. As a result of this, the speed of the object undergoes a small reduction and becomes smaller than (that) needed to attain circling along the satellite orbit. The path of the object thus undergoes a bending in the direction of the earth, and finally there follows an invasion into the denser layers of the atmosphere. The motion is subjected to a substantial braking action and finally the object falling by parachute, lands on the surface of the planet. The propelling materials are in such a case necessary only for a small braking of the cosmic object and a bending of its path in the direction of the earth.

It is necessary again to reflect what is the more advantageous braking by putting into operation the rocket engines at the perigee or at the apogee. From the point of view of experiments (experience) on earth, it appears that the perigee must constitute the point at which it is more advantageous to carry out the corresponding operation. Everyone, however, knows perfectly that it is easier to jump down from a table than from a window on the second floor. In astronautics life experiences from the surface of the earth are, however, without significance.

Let us assume that the satellite circles the earth along

the orbit assumed already in the preceding reasonings. After the starting of the rocket motor in the course of the next cycle it is about to carry out only half of a full encircling of the earth, and about to approach simultaneously to its (earth's) surface at a distance of only 35 km. At this height of the "conditioned perigee" the atmosphere of the earth is already so dense that the object which is however moving along its orbit that is so slightly directed downward toward the surface of the planet-encounters effective aerodynamic resistance. Precisely thus during the return of the rocket container from the lunar probe "Zond 5" did this height get selected in order to realize optimum aerodynamic braking.

One needs to reflect now about how much the speed of motion at the perigee must be decreased in order that the object after performing another half cycling of the earth along a downward reduced ellipse might approach its surface at a distance of 35 km. At this height its distance from the center of the earth will amount to:

$$r = 6378 + 35 = 6413 \text{ km}$$

The circular speed at the perigee of the original orbit is equal to:

$$v_{sp} = v_{so}\frac{r_o}{r_p} = 7912\sqrt{\frac{6378}{6697}} = 7721 \text{ m/s}$$

Using the already used expressions we attain a value of the exit speed of the object which it must attain in order to enter an orbit which approaches the surface of the earth at a distance of 35 km:

$$v_{wp} = v_{sp}\sqrt{\frac{2r}{r + r_p}} = 7721\sqrt{\frac{2\cdot 6413}{6413 + 6697}} = 7637 \text{ m/s}$$

The speed of motion at the perigee, which amounts to 9397 m/s must, then, in order to prepare for landing, be decreased to 7637 m/s, and thus by 1760 m/s. After carrying out a further circling on half of its orbit around the earth, the object approaches the surface of the globe at a distance of 35 km. Its speed of invasion into the atmosphere at a height of 35 km will amount then ((neglecting, besides, the minute resistance of the atmosphere appearing during descent from the satellite orbit.):

$$v_{35p} = v_{wp}\frac{r_p}{r} = 7637\cdot\frac{6697}{6413} = 7975 \text{ m/s}$$ 1)

If, moreover, the object is subject to (abrupt) braking at the apogee of the original orbit, the exit speed on the orbit of descent to the surface of the earth at a distance of 35 km must amount to:

$$v_{wa} = v_{sa}\sqrt{\frac{2r}{r + r_a}} = 4568\sqrt{\frac{2\cdot 6413}{6413 + 19134}} = 3237 \text{ m/s}$$

This speed is, however, smaller only by 52 m/s than the speed of circling along the satellite orbit at the apogee which amounts to 3289 m/s. The rocket motor must then decrease the actual speed of the object only by 52 m/s.

If one then initiates the operation of landing at the apogee at a height of 12756 km by the initial braking on the satellite orbit one needs less than 1/33 parts of that energy that is necessary during initial braking at the nearest-to-the-earth

point of the orbit, at a height of only 119 km.

Actually during the initial return at the apogee the speed of invasion to a height of 35 km will amount to:

$$v_{35a} = v_{wa} \frac{r_a}{r} = 3237 \frac{19134}{6413} = 9659 \text{ km/s}$$

and thus will be greater by 1684 m/s than in the case of original braking at the perigee. This does not have, however, any greater significance, since after invasion into the atmosphere further braking happens without consumption of propulsive materials, and only due to the resistance of this atmosphere. Even however in the case where there weren't any of it and further braking of the fall from a height of 35 km onto the surface of the planet would have to happen in the presence of use of the rocket motor, the total consumption of propulsive materials during the return from the apogee would be less than from the perigee.

THE PARADOXES OF THE PERIHELIUM AND APHELIUM

The aerodynamic phenomena appearing at the perigee and apogee exist not only in relation to the earth, but appear in the case of every other heavenly body that constitutes the central body of a dynamic system. Especially interesting such phenomena exist in the solar system, when the sun appears in the role of the central body of the system, and the cosmic object finds itself under the action of the gravitational fields of the earth and the sun. A situation of this type takes place in the case of the determination of the speed of an object which is about to abandon the solar system for ever.

The eccentricity of the elliptic orbit of the earth around the sun is the reason for the non-uniform speed of its circling motion. In January our planet passes thru the point of its orbit closest to the sun--the **perihelion**. Then, however, the speed of motion of our globe is least. Correspondingly, in July this speed is greatest, since then the earth passes the point of its orbit most distant from the sun--its **aphelion**.

The speed of the gradual motion of the earth at the **perihelion** amounts to:

$$w_p = \bar{w} \cdot \sqrt{\frac{1 + e}{1 - e}}$$

where w_p is the average speed of motion of the earth along its orbit around the sun?, equal to 29,766 km/s, where e = 0.01687 constitutes the eccentricity of this orbit. If we substitute the given values into the expression, there is obtained the value of the gradual speed of motion of the earth at the **perihelion** w_p = 30.268 km/s. At the **aphelion**, moreover, the speed of this motion amounts to:

$$w_a = \bar{w} \sqrt{\frac{1-e}{1 + e}} = 29.272 \text{ km/s}$$

An object sent out from the earth which is about to leave the solar system for ever, must have an absolute minimum speed of 42.451 km/s. This does not mean, however, completely that the rocket motor must add this whole speed to the object. The take-off, however, is about to happen from the earth--a body which is circling the sun and which has alone already a definite precise speed of gradual motion with respect to the central star of the system. The cosmic object must then attain only an additional speed that constitutes the difference between the minimum speed

of flight from the solar system, and the speed of circling of the earth around the sun. At the perihelion this difference amounts to: 42.451 - 30.268 = 12.183 km/s. Since, however, at the aphelion the speed of gradual motion of the earth amounts only to 29.272 km/s, the consumption of propulsive materials in the case of the sending out of an object beyond the solar system from the perihelion of the orbit of our planet is less, in spite of the more powerful action of the force of gravity of the sun.

An analogous situation appears when there is taken into consideration here also the gravitational attraction of the earth. The speed of flight from the earth into infinity [2] the so-called "third cosmic velocity", which the object must attain that takes off from the surface of our planet, amounts to, at the aphelion --at the beginning of July-- to 16.758 km/s, at the perihelion --at the beginning of January-- to 16.541 km/s. The third cosmic speed increases, considering this, in the first half year gradually by 215 m/s, only to decrease to its original value in the course of the next half year.

If it is desired that an object taking off from the earth should reach the sun by a simple path, one needs to add to it a specific substantial velocity (speed) which let us designate here as the "solar cosmic speed" [3]. In a flight of this type the object must not only overcome the force of the earth's gravity, but also be additionally so accelerated that the component of its velocity added to it by the circling motion of the earth undergoes neutralization. Since the component there, as already specified, is greater at the perihelium than at the aphelium,

also for these two points one obtains different magnitudes for the solar cosmic speed. If one takes into consideration the force of gravity of the earth, then at the perihelion this speed amounts to 32.270 km/s and at the aphelion, moreover, it is less by 0.932 km/s.

Thus, less energy needs to be consumed in order to throw an object out onto the sun, when the earth is most distant from the sun, than when it is at the least distance from it. The solar cosmic speed decreases in the course of the first half year, the third cosmic speed, however, increases. In the second half year the situation is reversed.

The instances of paradoxes of the perehelion and the aphelion show that the third and solar cosmic speeds to some extent depend on the season. In every day life the changes of the seasons are noted in the changes of weather and vegetation, in astronautics---in changes in the orbital speed and distance of the sun from the earth.

The magnitudes of the third and solar cosmic speeds for other planets of the solar system also change with their circling around the central star of the system, and thus in the course of the elapse of their planetary year. For some of these planets the anual variations of the corresponding speeds are small, for others, for instance for Mercury,--considerable. On precisely this planet the third cosmic speed changes in the course of the Mercury half-year, that lasts 44 earth (24 hour) days, from

23.2 km/s to barely 17.5 km/s, while in this same time the solaR cosmic speed increases from 38.1 km/s up to 59.1 km/s.

Thus at last we can draw a paradoxical final conclusion, that one can more easily penetrate onto a heavenly body from the apocentrum of the circulating orbit surrounding it, and thus from the most distant point from it, than from the closest point --the pericentrum. Moreover, from the point of the earth's orbit closest to the sun--the perihelion, where the force of gravitatioal attraction of this star is greatest one can more easily extricate himself beyond the solar system than from the aphelion, at which the earth is most distant from it.

BIBLIOGRAPHY

1. A Szternfeld: From an artificial satellite to interplanetary flights. 2nd publication Fizmatgiz (Physics and Math state publishing) Moscow 1959 pg 91

2. A. Szternfeld, Introduction to Cosmonautics, Moscow-Leningrad 1937 pgs. 152-154

3. A. Szternfeld: Artificial Satellites, Teubner Pubco, Lipsk 1959 pg 217

4. A Szternfeld: Flight in the Cosmos, Pub of the Ministry foR National Defense, Berlin 1956

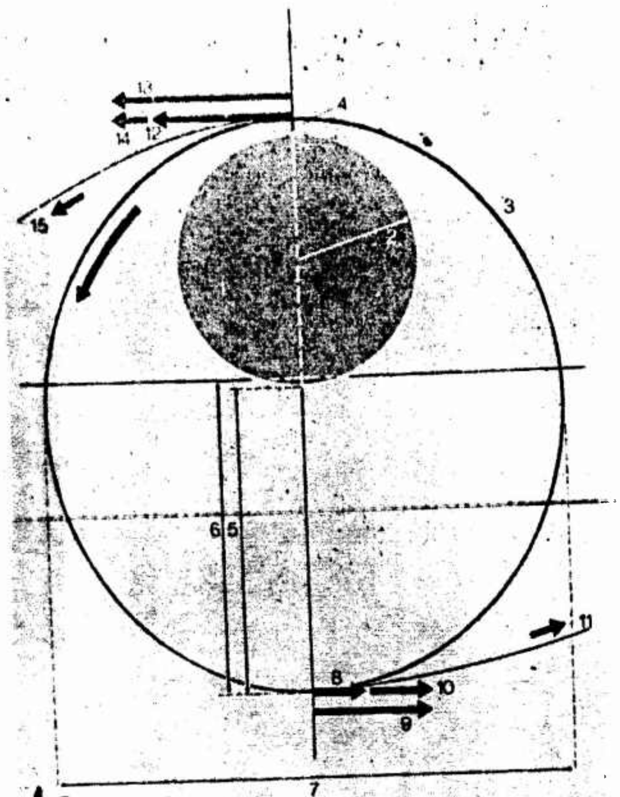
5. A Szternfeld: Interplanetary Flights, Foreign Literature Publishing Moscow 1959.

NOTES BY THE EDITORIAL STAFF

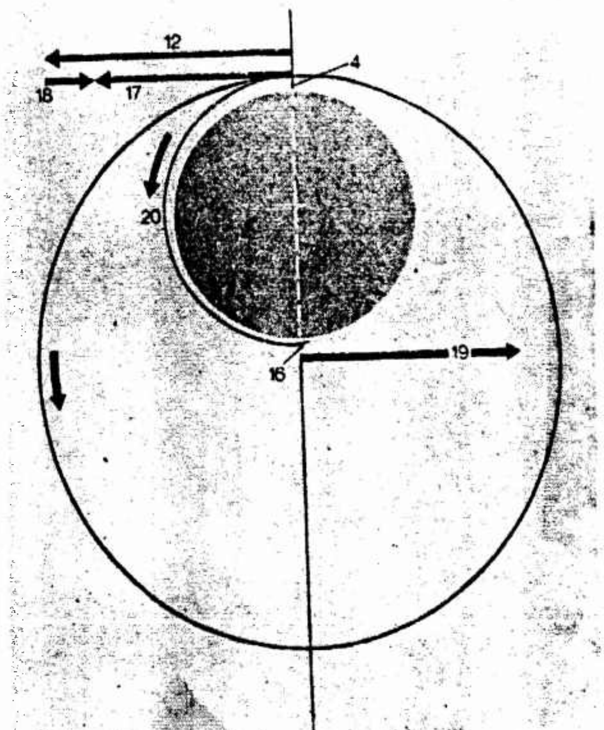
1. In practice, invasion into the atmosphere follows at more or less around 120 km, and the maximum braking happens on the section of the path within distances of around 80-90 km from the surface of the earth. In the article we are concerned, however, not about details of the course of the operation of the corresponding changes of the orbit and its factual course, but about the more general problem of certain paradoxes of astrodynamics. During practical realization of the return, it often is important, however, that the invasion into the atmosphere should occur with the very least speed, especially in the case of flights with crews.

2. Here we are concerned with a flight within the limits of the galaxy, to which the sun belongs. In order to abandon the galaxy, one needs during the takeoff from the earth, to add to the object a greater speed, called the "fourth cosmic speed" The absolute value of this speed (velocity) amounts to 350 km/s. Exploiting, however, the speed of the motion of the sun with respect to the center of mass of the galaxy, it is sufficient xxxxx that the object attain at the takeoff from the earth a speed of only around 130 km/s.

3. The author gives this speed the name: "fourth cosmic speed". In order not to confuse it with the speed mentionned in note #2 that is indispensible for leaving the galaxy, we have accepted here the term "solar cosmic speed".



1a



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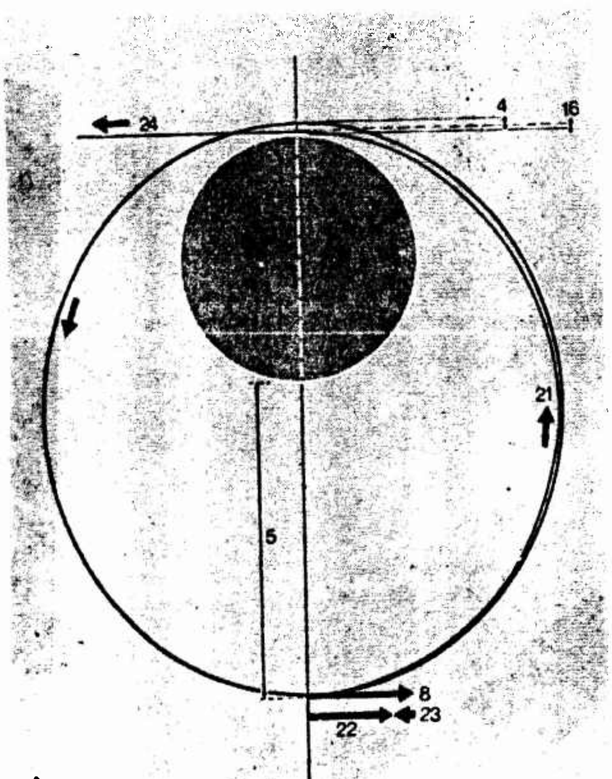
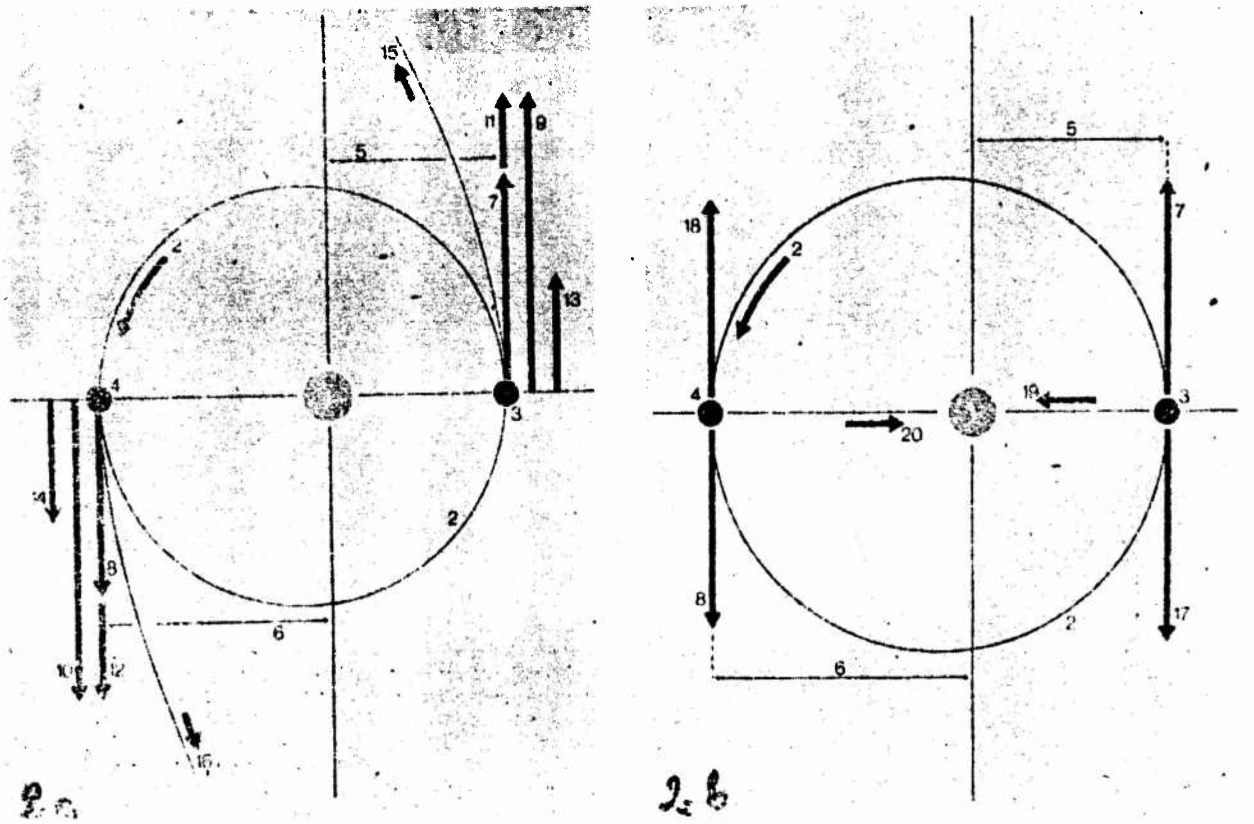


1c

(callouts next page)

(diagram callouts)(pg #5)

1a paradox of the perigee; 1b paradox of the apogee,--return from the perigee 1 c paradox of the apogee return from the apogee 1- earth 2- equatorial radius of the earth r_0 = 6378km 3- orbit of the satellite 4- apogee h_a = 12756 km 6-large semi-axisof the elliptic orbit a=12915 km, 7- small axis of the elliptic orbit 2b = 22640 km 8- speed of the satellite at the apogee v_a= 3289 m/s 9- second cosmic speed at the apogee v_{ua} = 6460 m/s 10- speed of departure at the apogee v_{oa}=3171 m/s 11-parabolic orbit ((of flight) at the apogee 12- speed of the satellite at the perigee v_p = 9397 m/s 13- the second cosmic speed at the perigee v_{up} = 10918 m/s 14- speed of departure at the perigee v_{op} = 1522 m/s 15- parabolic orbit ((of flight) at the perigee 16- conditioned height of the perigee 35 km 17- exit speed from an orbit around the earth at the perigee v_{wp} = 7637 m/s 18- retrograde speed at the perigee added by the object's rocket motor 1760 m/s 19- speed of invasion int the dense layers of the atmosphere during return from the perigee v_{35p} = 7975m/s 20- half elliptic orbit during return from the perigee 21- half elliptic orbit during return from the apogee 22- exit speed from an orbit around the earth at the apogee v_{wa} = 3237 m/s 23- retrograde speed at the apogee added by the object's rocket motor 52 m/s 24- speed of invasion into the dense layers of the atmosphere during return from the apogee v_{35a} = 9659 m/s



2. a. Paradoks aphelium,
b. Paradoks peryhelium
1 — Słońce, 2 — orbita Ziemi, 3 — Ziemia w peryhelium, 4 — Ziemia w aphelium, 5 — odległość Ziemi od Słońca w peryhelium 147 mln km, 6 — odległość Ziemi od Słońca w aphelium 152 mln km, 7 — prędkość postępowa Ziemi w peryhelium w_p=30,268 km/s, 8 — prędkość postępowa Ziemi w aphelium w_a=29,272 km/s, 9 — prędkość paraboliczna (ucieczki) względem Słońca w peryhelium 42,451 km/s, 10 — prędkość paraboliczna (ucieczki) względem Słońca w aphelium 41,747 km/s, 11 — różnica między prędkością paraboliczną (ucieczki) a prędkością postępową w peryhelium 12,183 km/s, 12 — różnica między prędkością paraboliczną (ucieczki) a prędkością postępową w aphelium 12,475 km/s, 13 — trzecia prędkość kosmiczna w peryhelium 16,541 km/s, 14 — trzecia prędkość kosmiczna w aphelium 16,758 km/s, 15 — orbita paraboliczna odlotu poza Układ Słoneczny z peryhelium, 16 — orbita paraboliczna odlotu poza Układ Słoneczny z aphelium, 17 — słoneczna prędkość kosmiczna w peryhelium 32,270 km/s, 18 — słoneczna prędkość kosmiczna w aphelium 31,388 km/s, 19 — prosty tor ku Słońcu z peryhelium, 20 — prosty tor ku Słońcu z aphelium.

6

callouts next page

(diagram callouts pg #6)

2a - paradox of the aphelium 2b- paradox of the perihelium

1- the sun 2- orbit of the earth 3- the earth at the perih helium (helion) 4- the earth at the aphelium 5- distance of the earth from the sun at the perihelium 147 mln km 6- dist tance of the earth from the sun at the aphelium 152 mln km

7- gradual speed of the earth at the perihelium w_p = 30.268 km/s

8- gradual speed of the earth at the aphelium w_a = 29.272 km/s

9- parabolic speed (vel)((of flight) with respect to the sun at the perihelium 42.451 km/s 10- parabolic speed((of flight) with respect to the sun at the aphelium 41.747 km/s

11- difference between the parabolic speed ((of flight) and the gradual speed (of the earth) at the perihelium 12.183 km/s

12- difference between the parabolic speed((of flight) and the gradual speed at the aphelium 12.475 km/s 13- third cosmic speed at the perihelium 16.541 km/s 14- third cosmic speed at the pahelium 16.758 km/s 15- parabolic object of departure beyond the Solar System from the perihelium 16- parabolic or bit of departure beyond the Solar System from the aphelium

17- solar cosmic speed at the perihelium 32.270 km/s

18- solar cosmic speed at the aphelium 31.388 km/s

19- simple path towards the sun from the perihelium

20- simple path towards the sun from the aphelium

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ORGANIZATION		MICROFICHE	ORGANIZATION		MICROFICHE
A205	DMATC	1	E053	AF/INAKA	1
A210	DMAAC	2	E017	AF/ RDXTR-W	1
B344	DIA/RDS-3C	8	E404	AEDC	1
C043	USAMIIA	1	E408	AFWL	1
C509	BALLISTIC RES LABS	1	E410	ADTC	1
C510	AIR MOBILITY R&D LAB/FIO	1	E413	ESD	2
				FTD	
C513	PICATINNY ARSENAL	1		CCN	1
C535	AVIATION SYS COMD	1		ETID	3
C557	USAIIC	1		NIA/PHS	1
C591	FSTC	5		NICD	5
C619	MIA REDSTONE	1			
D008	NISC	1			
H300	USAICE (USAREUR)	1			
P005	ERDA	2			
P055	CIA/CRS/ADD/SD	1			
NAVORDSTA (50L)		1			
NAVWPNSCEN (Code 121)		1			
NASA/KSI		1			
544 IES/RDPO		1			
AFIT/LD		1			

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